US009620849B2

(12) United States Patent
Azad et al.

(10) Patent No.: US 9,620,849 B2
(45) Date of Patent: Apr. 11, 2017

(54) COUPLED-FEED WIDEBAND ANTENNA

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 264 days.

(21) Appl. No.: **13/908,823**

(22) Filed: **Jun. 3, 2013**

(65) **Prior Publication Data**

US 2014/0354483 A1 Dec. 4, 2014

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 9/30	(2006.01)
H01Q 5/385	(2015.01)

(52) **U.S. Cl.**

CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/385*** (2015.01); ***H01Q 9/30*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/0407; H01Q 5/385; H01Q 1/243; H01Q 9/30

USPC 343/702

See application file for complete search history.

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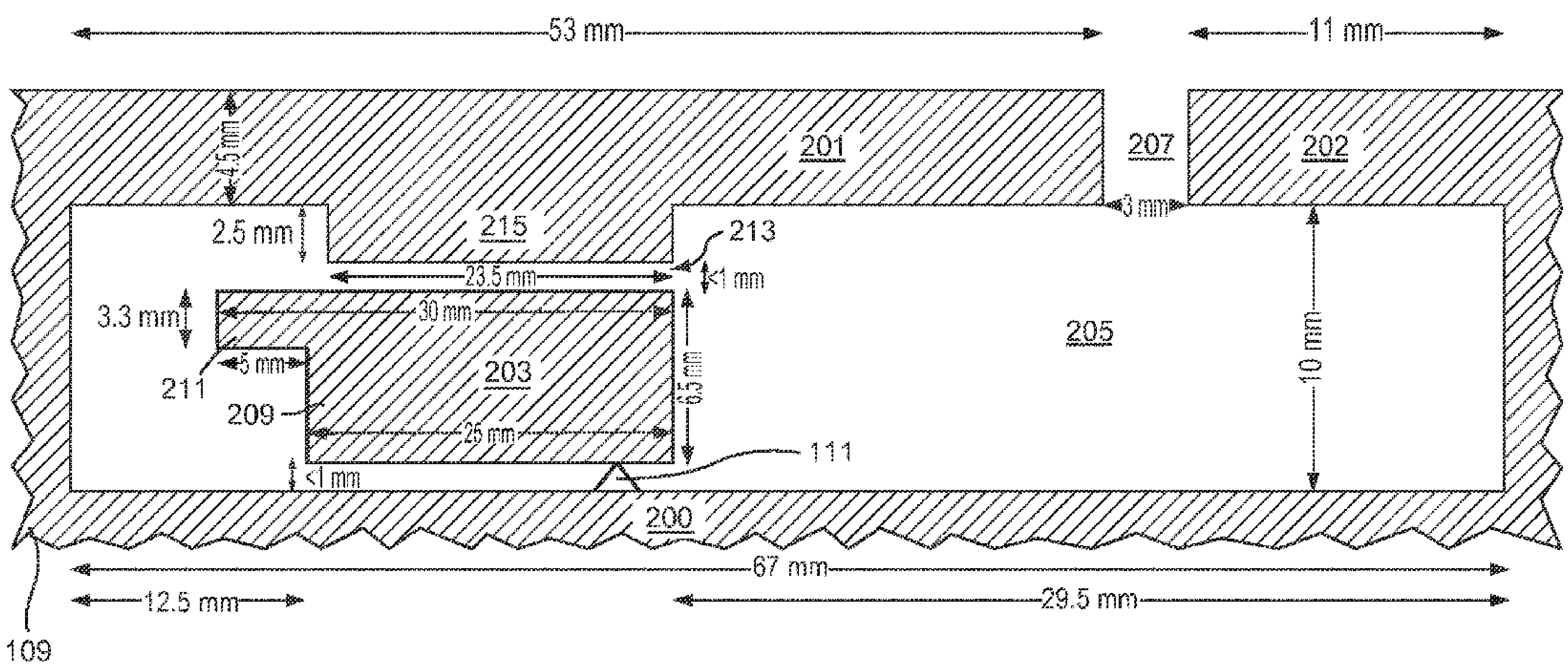
(57) **ABSTRACT**

A device having a coupled-feed wideband antenna is provided. The device comprises: a chassis comprising as a ground plane; an antenna feed, a ground side of the antenna feed connected to the ground plane; and, an antenna comprising: a first radiating arm configured for generating a first resonance at a first frequency, the first radiating arm connected to the chassis and hence the ground plane; a second radiating arm configured for generating a second resonance at a second frequency higher than the first frequency, the second radiating arm connected to the ground plane; and a third radiating arm configured for generating a third resonance at a third frequency higher than the second frequency, the first radiating arm capacitively coupled to the third radiating arm, and the third radiating arm connected to a positive side of the antenna feed.

16 Claims, 11 Drawing Sheets



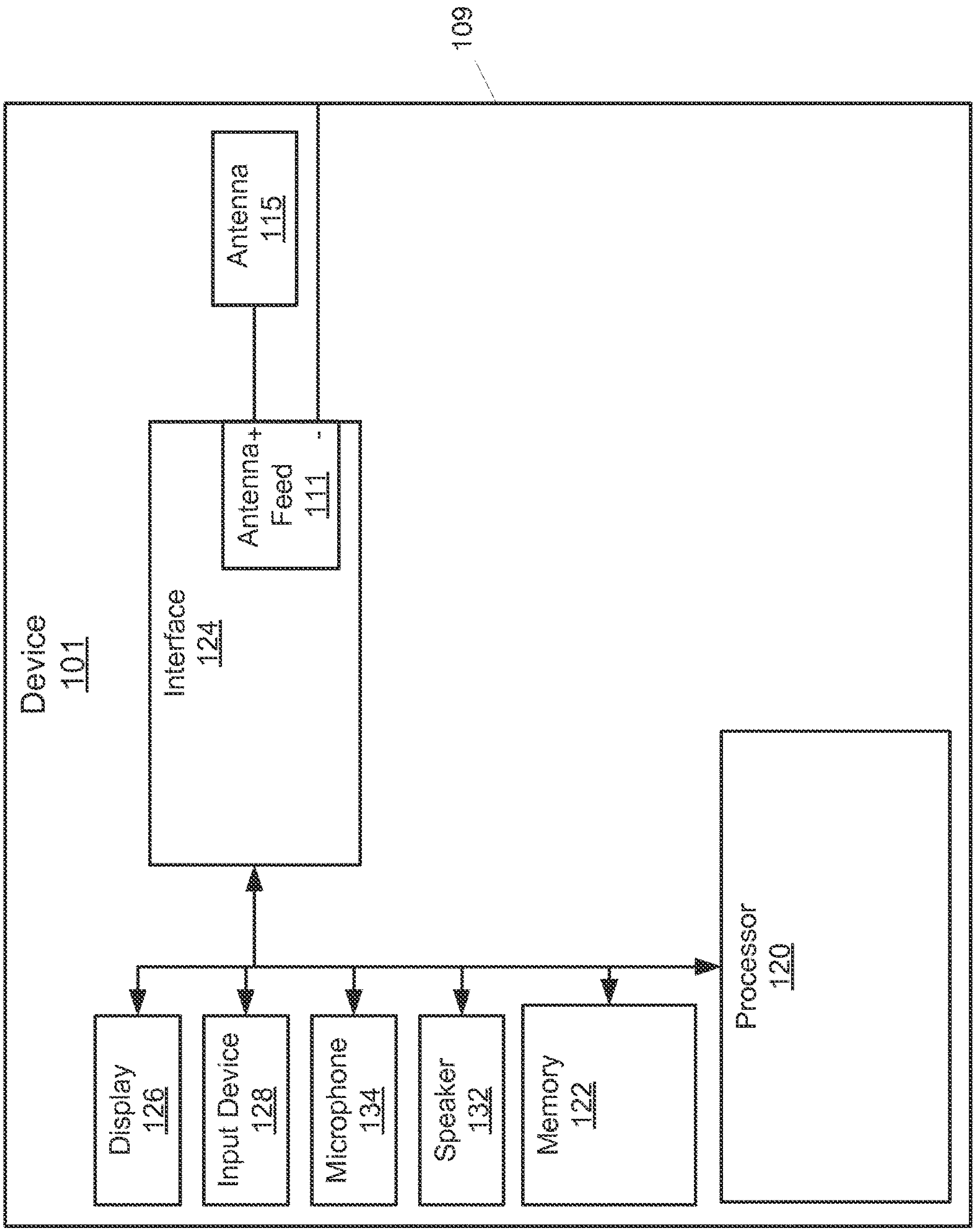

109
Device
101
Antenna
115
Interface
124
Antenna+
Feed
111
-
Display
126
Input Device
128
Microphone
134
Speaker
132
Memory
122
Processor
120

Fig. 1

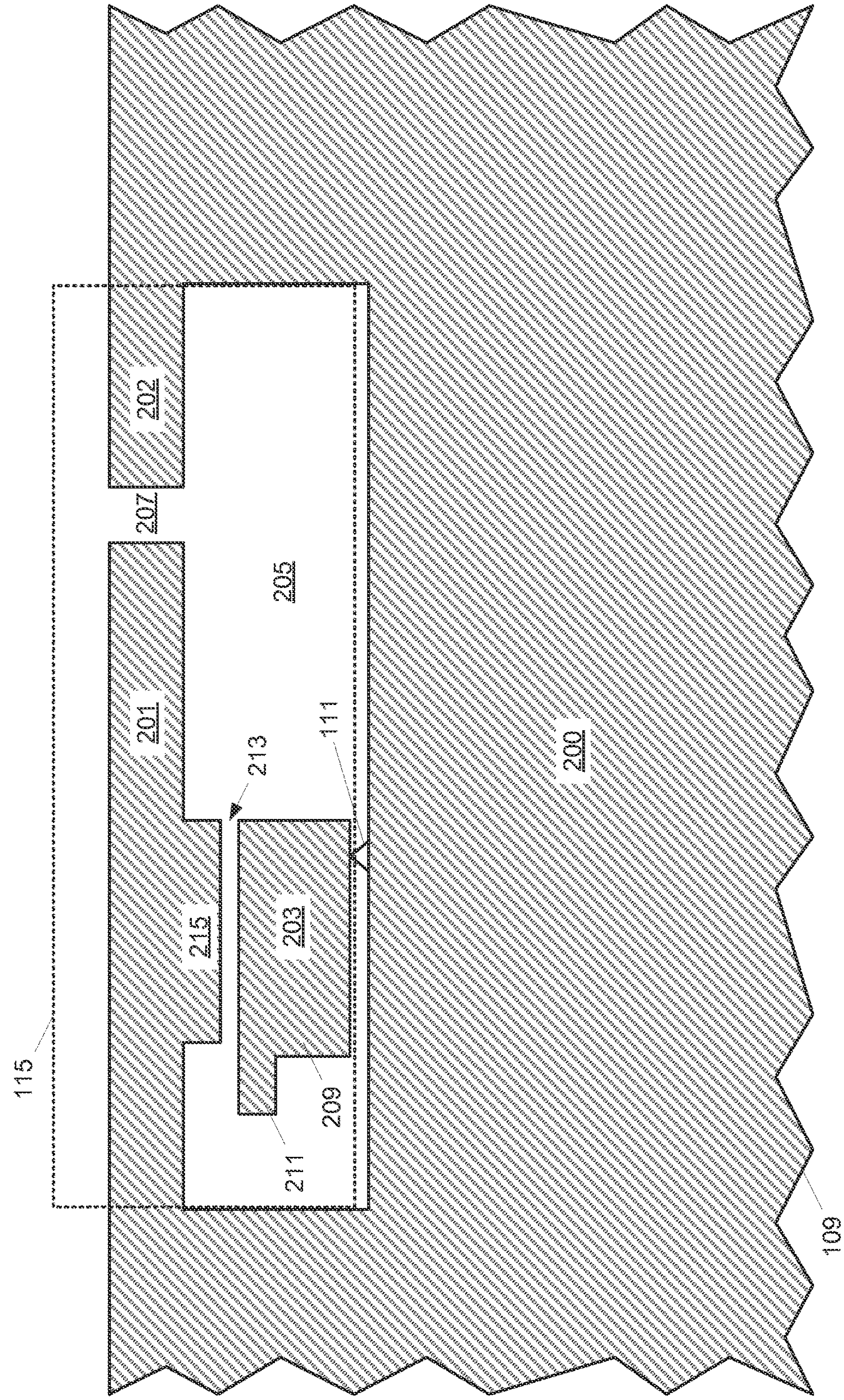
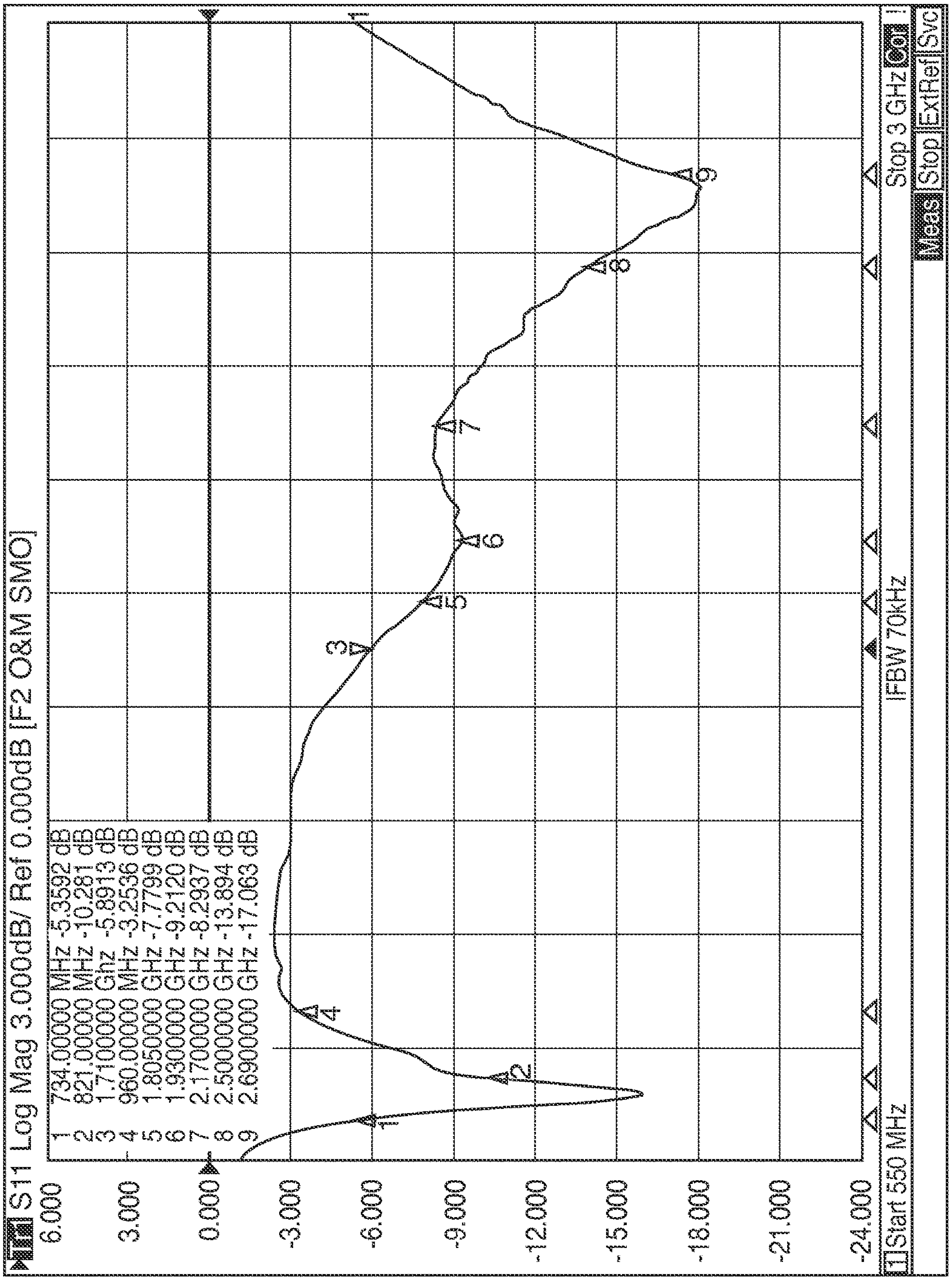


Fig. 2



S11 Log Mag 3.000dB/ Ref 0.000dB [F2 O&M SMO]
6.000
3.000
0.000
-3.000
-6.000
-9.000
-12.000
-15.000
-18.000
-21.000
-24.000
1 734.00000 MHz -5.3592 dB
2 821.00000 MHz -10.281 dB
3 1.7100000 Ghz -5.8913 dB
4 960.00000 MHz -3.2536 dB
5 1.8050000 GHz -7.7799 dB
6 1.9300000 GHz -9.2120 dB
7 2.1700000 GHz -8.2937 dB
8 2.5000000 GHz -13.894 dB
9 2.6900000 GHz -17.063 dB
1 Start 550 MHz
IFBW 70kHz
Stop 3 GHz
Meas
Stop
ExtRef
Svc

FIG. 3

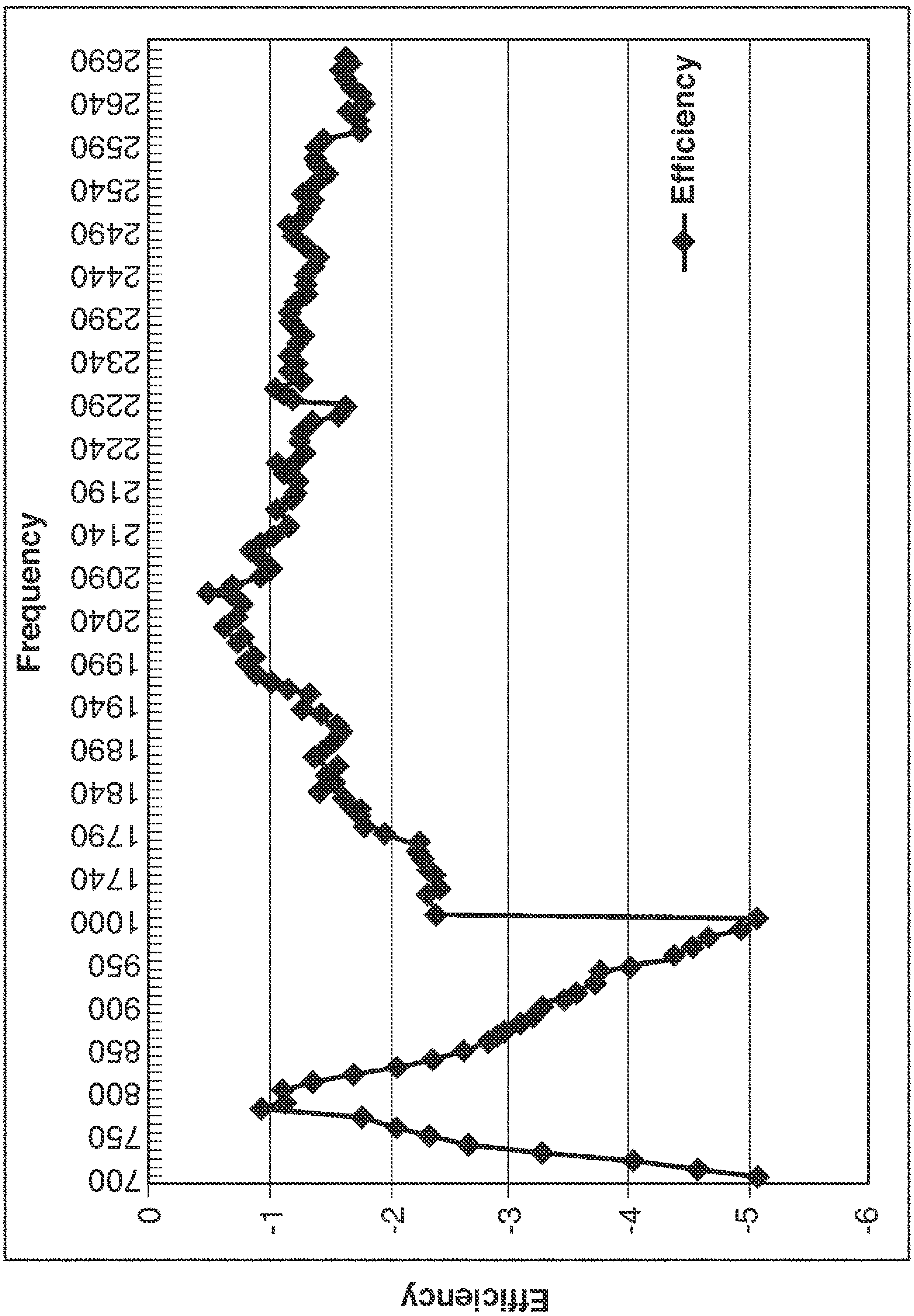

Frequency
Efficiency
Efficiency
700
750
800
850
900
950
1000
1740
1790
1840
1890
1940
1990
2040
2090
2140
2190
2240
2290
2340
2390
2440
2490
2540
2590
2640
2690
0
-1
-2
-3
-4
-5
-6

FIG. 4

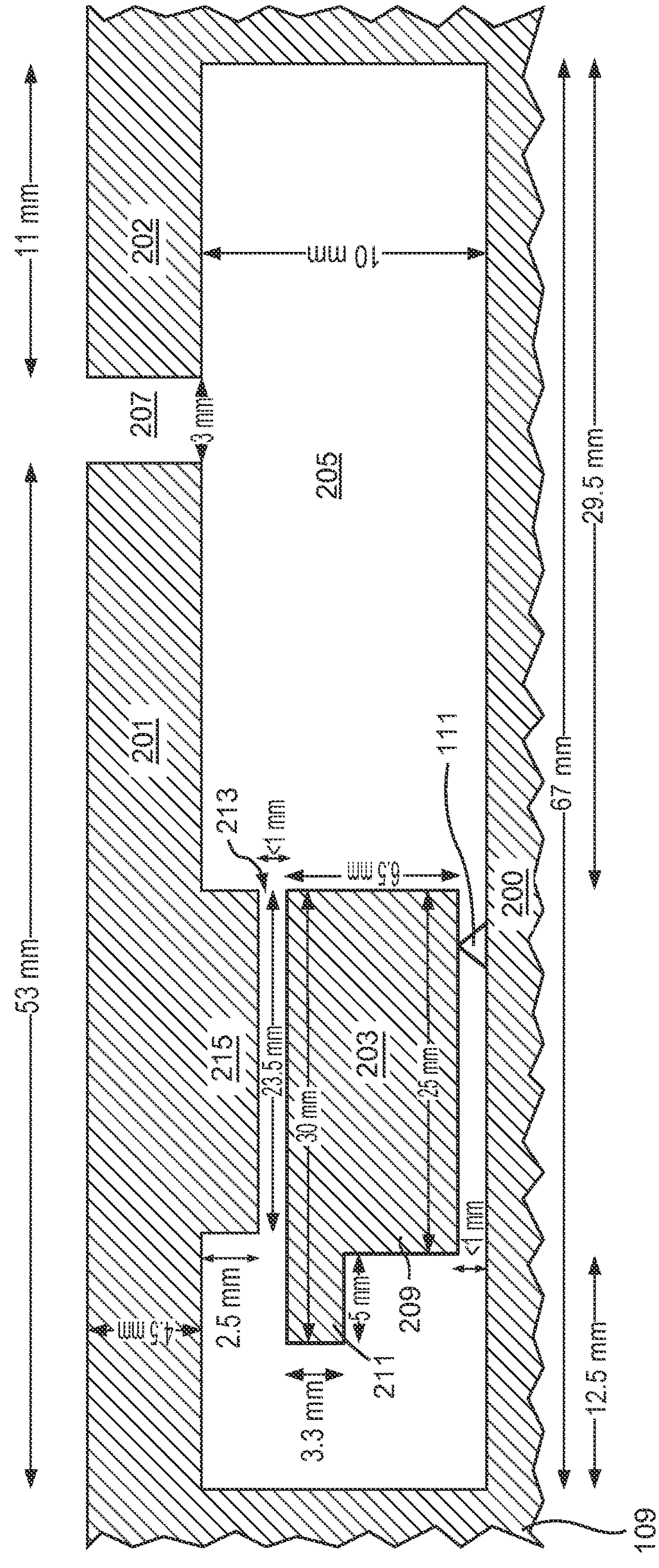

11 mm
202
10 mm
207
3 mm
205
201
53 mm
67 mm
29.5 mm
111
213
<1 mm
6.5 mm
200
215
203
23.5 mm
30 mm
25 mm
<1 mm
2.5 mm
4.5 mm
5 mm
209
211
3.3 mm
12.5 mm
109

FIG. 5

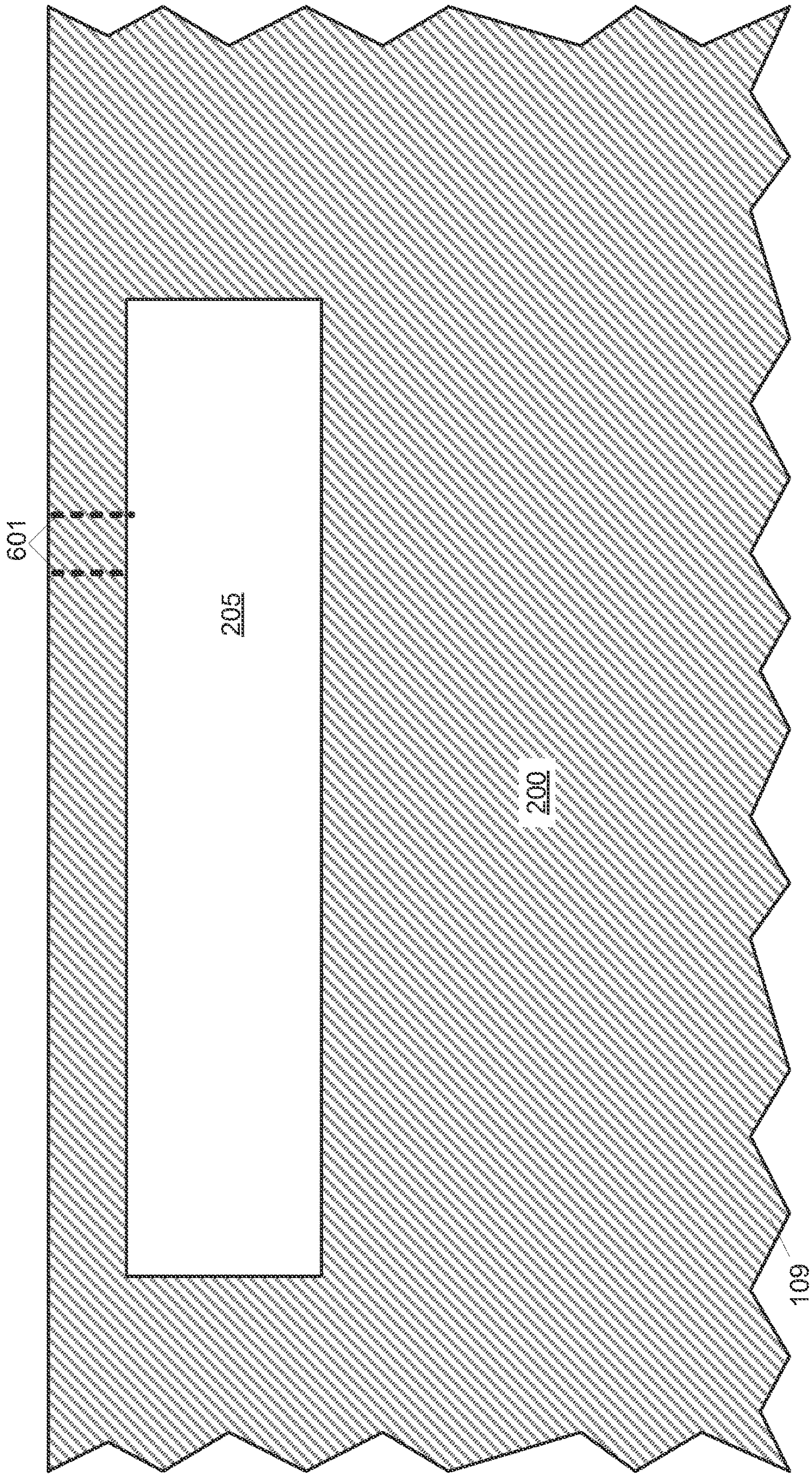


Fig. 6

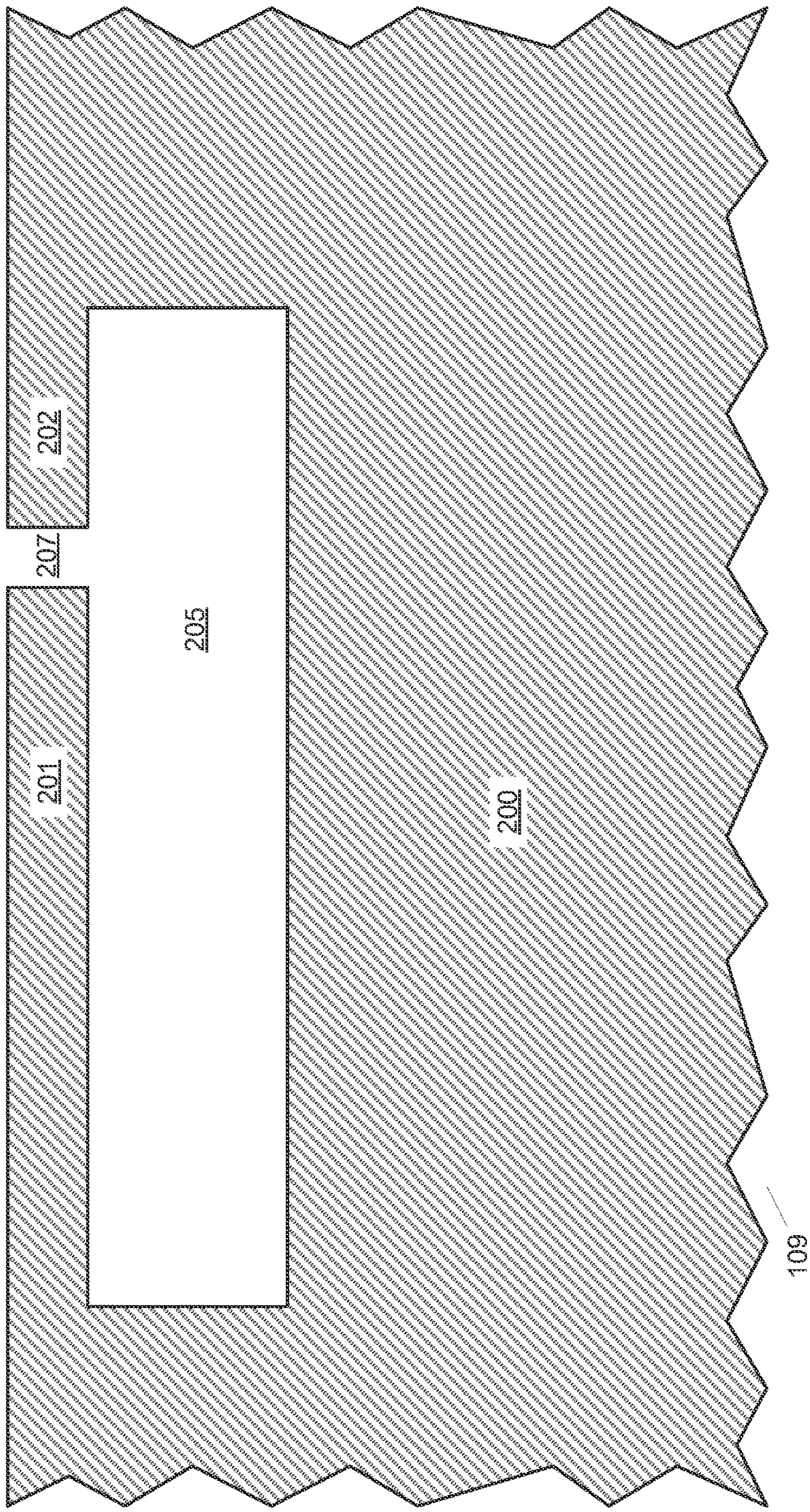


Fig. 7

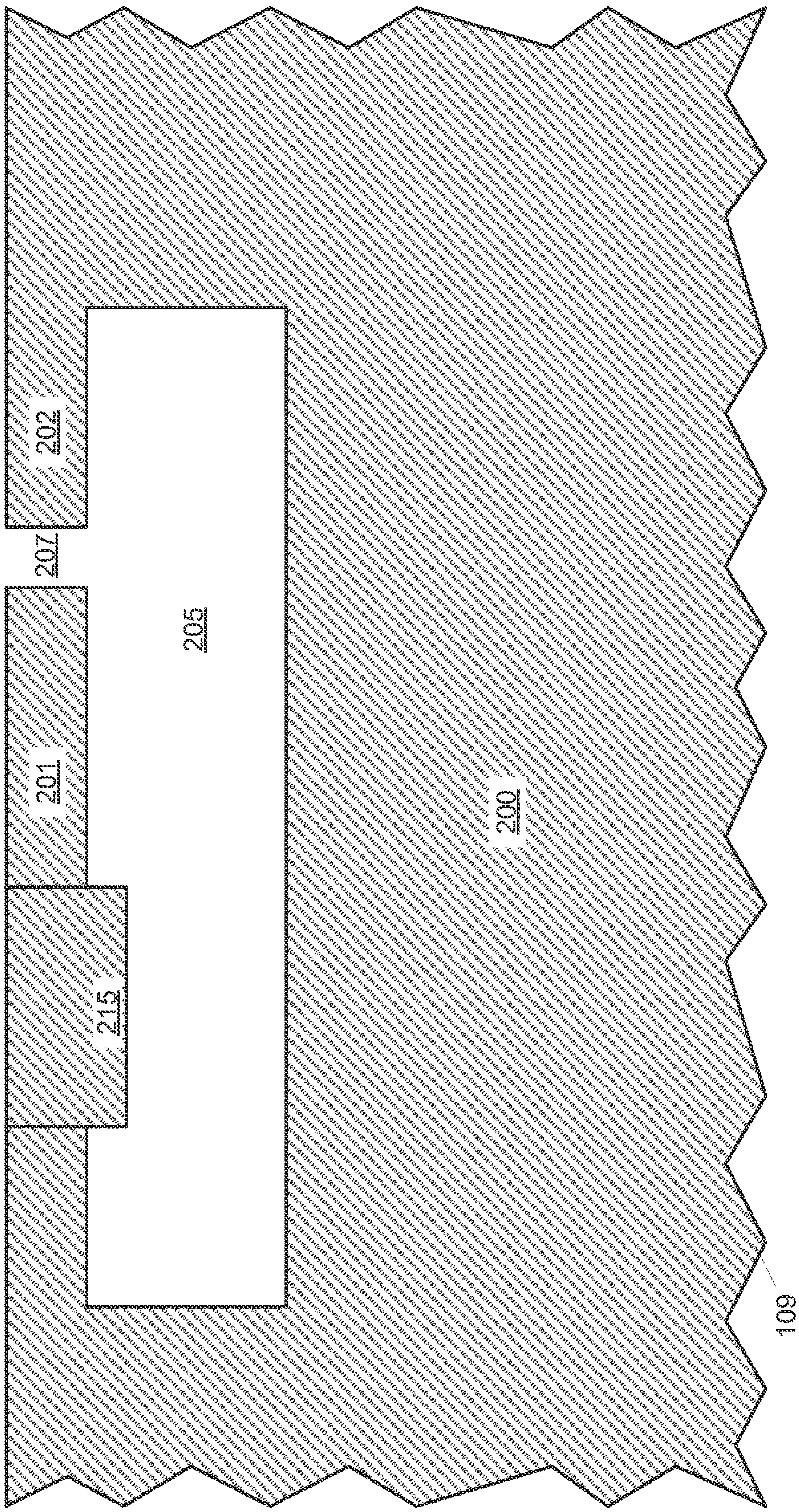


Fig. 8

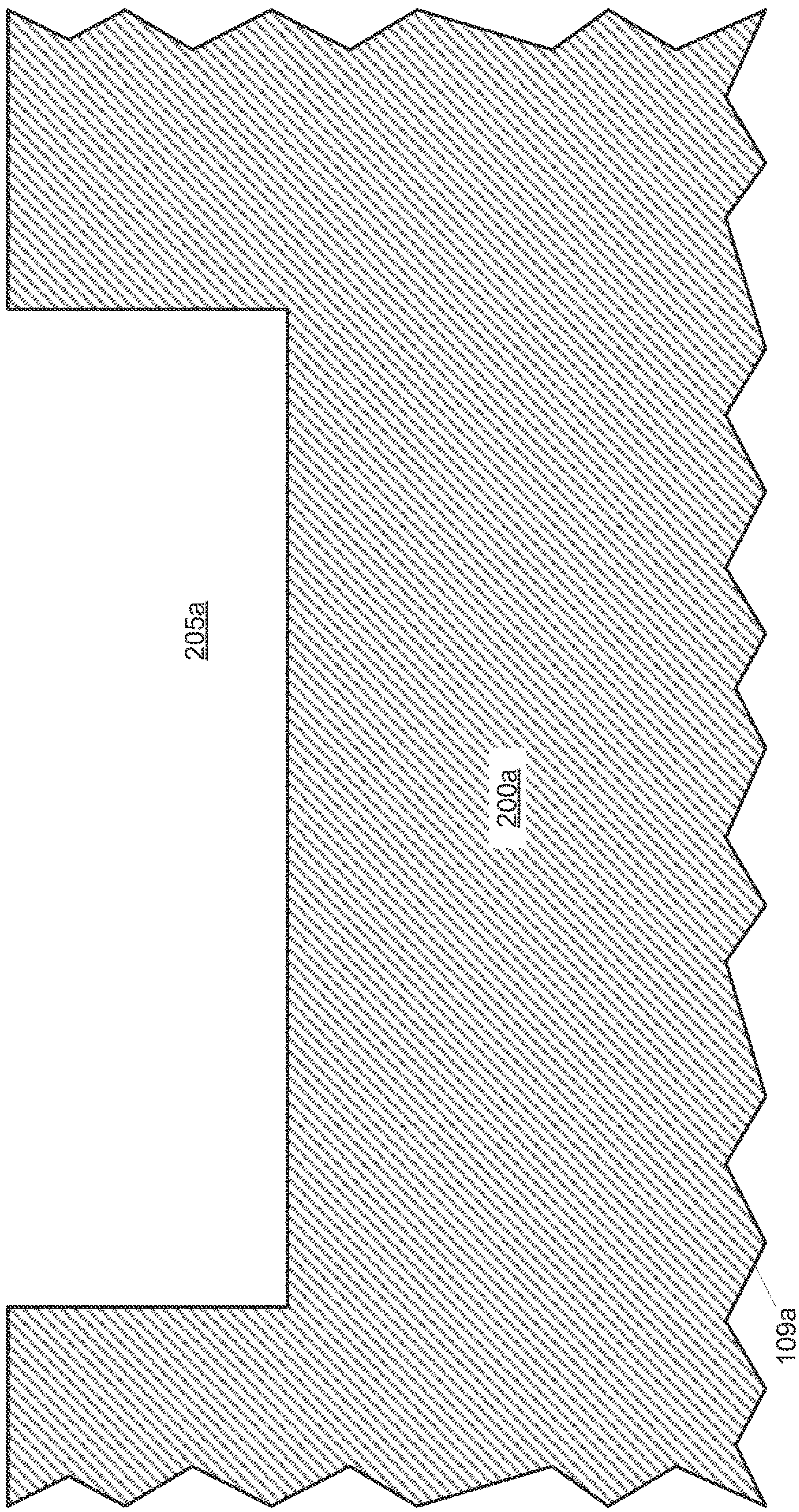
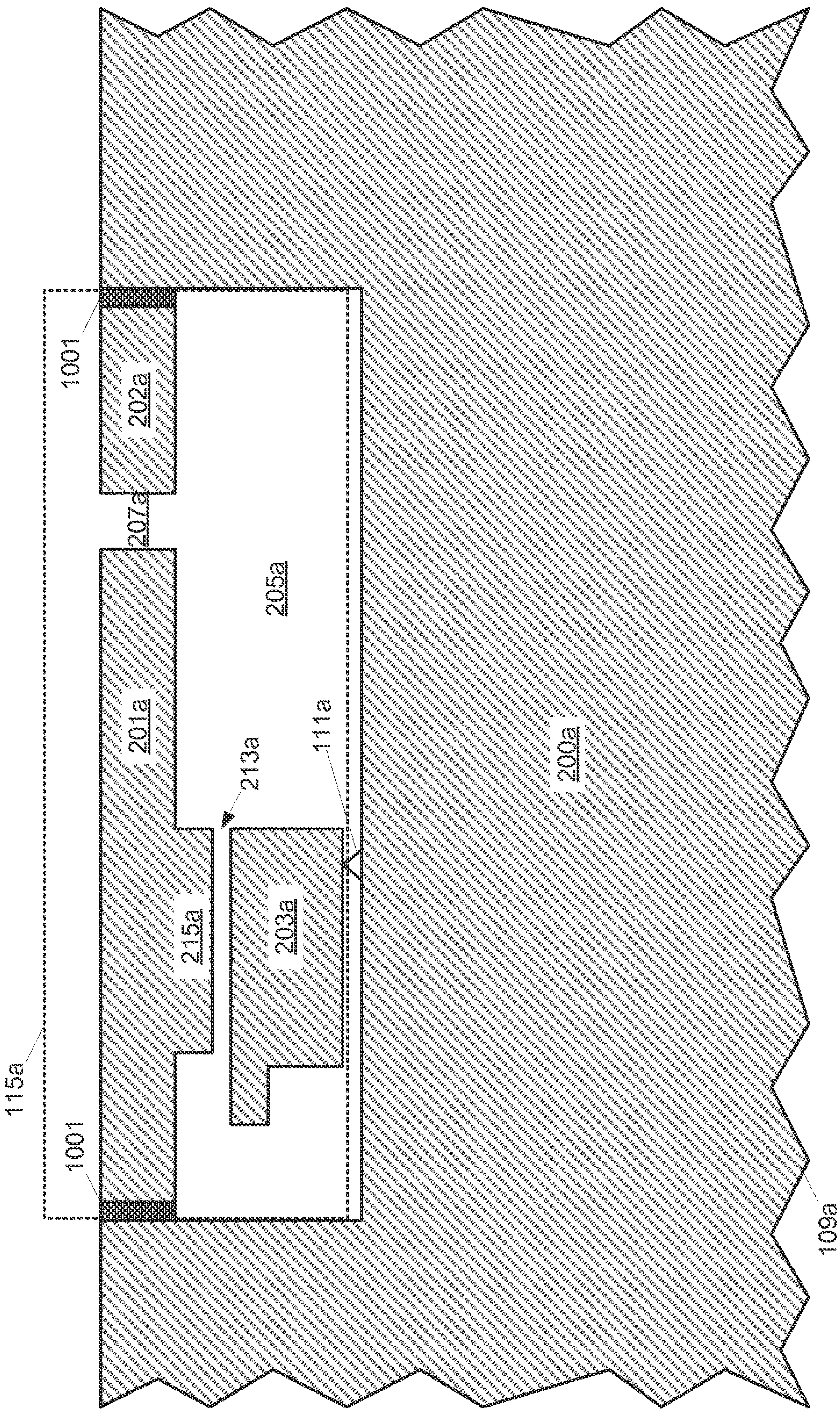


Fig. 9



1001
202a
207a
205a
201a
213a
111a
200a
215a
203a
115a
1001
109a

Fig. 10

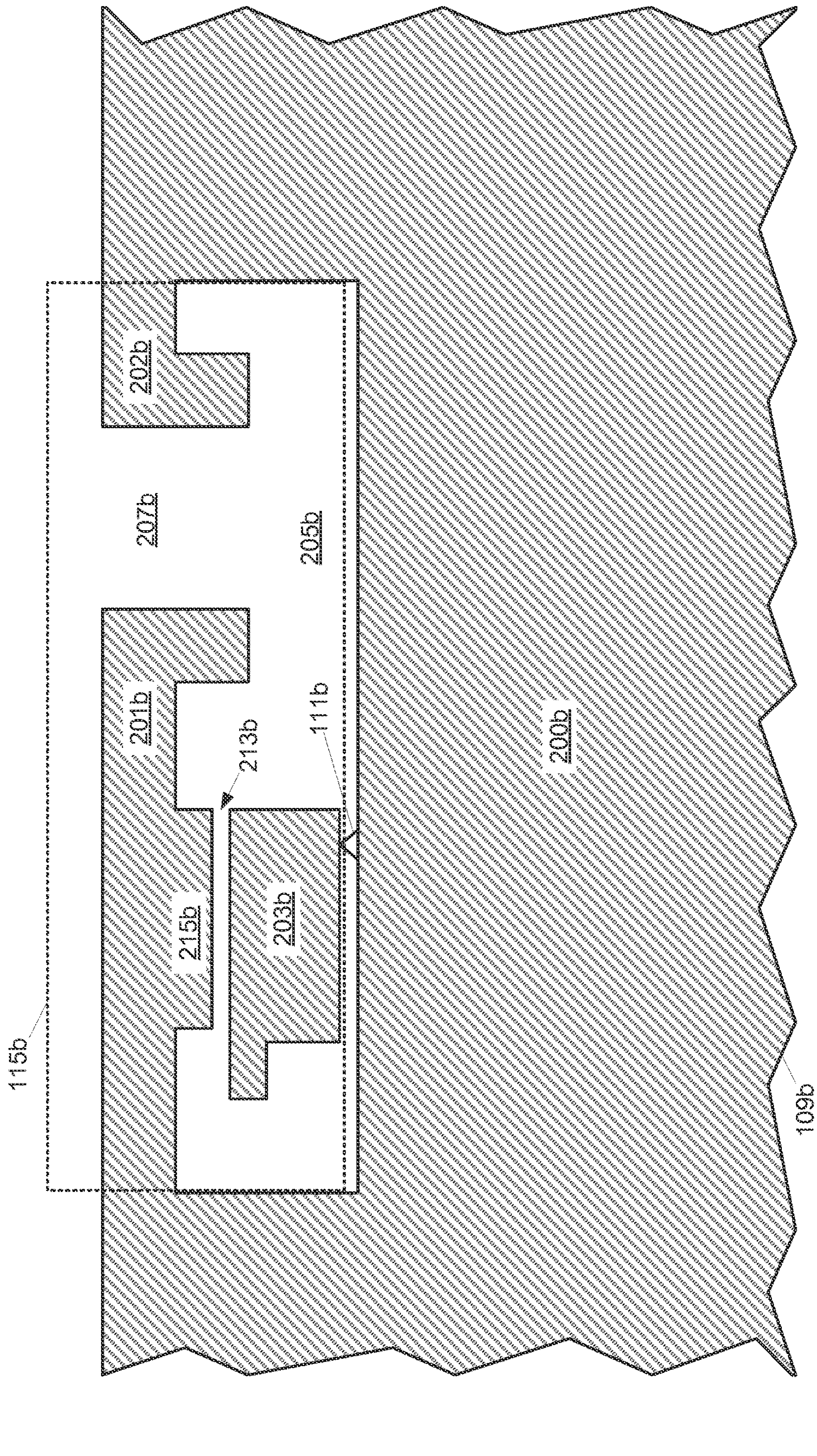


Fig. 11

COUPLED-FEED WIDEBAND ANTENNA

FIELD

The specification relates generally to antennas, and specifically to a coupled-feed wideband antenna.

BACKGROUND

Current mobile electronic devices, such as smartphones, tablets and the like, generally have different antennas implemented to support different types of wireless protocols and/or to cover different frequency ranges. For example, LTE (Long Term Evolution) bands, GSM (Global System for Mobile Communications) bands, UMTS (Universal Mobile Telecommunications System) bands, and/or WLAN (wireless local area network) bands, cover frequency ranges from 700 to 960 MHz, 1710-2170 MHz, and 2500-2700 MHz and the specific channels within these bands can vary from region to region necessitating the use of different antennas for each region in similar models of devices. This can complicate both resourcing and managing the different antennas for devices in each region.

BRIEF DESCRIPTIONS OF THE DRAWINGS

For a better understanding of the various implementations described herein and to show more clearly how they may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings in which:

FIG. **1** depicts a schematic diagram of a device that includes a coupled-feed wideband antenna, according to non-limiting implementations.

FIG. **2** depicts a schematic diagram of the coupled-feed wideband antenna of FIG. **1**, according to non-limiting implementations.

FIG. **3** depicts a return-loss curve of the coupled-feed wideband antenna of FIG. **1**, according to non-limiting implementations.

FIG. **4** depicts an efficiency curve of the coupled-feed wideband antenna of FIG. **1**, according to non-limiting implementations.

FIG. **5** depicts dimensions of the coupled-feed wideband antenna of FIG. **1** used to produce the return-loss curve of FIG. **3** and the efficiency curve of FIG. **4**, according to non-limiting implementations.

FIG. **6** depicts a portion of the chassis of the device of FIG. **1** prior to being adapted to include the coupled-feed wideband antenna, according to non-limiting implementations.

FIG. **7** depicts the portion of the chassis of FIG. **6** adapted to form a first radiating arm and a second radiating arm of the coupled-feed wideband antenna, according to non-limiting implementations.

FIG. **8** depicts the chassis of FIG. **7** further adapted to widen a portion of a length of the first radiating arm, according to non-limiting implementations.

FIG. **9** depicts an alternative portion of the chassis of the device of FIG. **1** prior to being adapted to include a coupled-feed wideband antenna, according to non-limiting implementations.

FIG. **10** depicts the portion of the chassis of FIG. **9** adapted to include the coupled-feed wideband antenna, according to non-limiting implementations.

FIG. **11** an alternative coupled-feed wideband antenna, according to non-limiting implementations.

DETAILED DESCRIPTION

The present disclosure describes examples of a coupled-feed wideband antenna that can resonate at three frequency responses to cover bands that include channels for LTE bands, GSM bands, UMTS bands, and/or WLAN bands in a plurality of geographical regions.

In this specification, elements may be described as "configured to" perform one or more functions or "configured for" such functions. In general, an element that is configured to perform or configured for performing a function is enabled to perform the function, or is suitable for performing the function, or is adapted to perform the function, or is operable to perform the function, or is otherwise capable of performing the function.

Furthermore, as will become apparent, in this specification certain elements may be described as connected physically, electronically, or any combination thereof, according to context. In general, components that are electrically connected are configured to communicate (that is, they are capable of communicating) by way of electric signals. According to context, two components that are physically coupled and/or physically connected may behave as a single element. In some cases, physically connected elements may be integrally formed, e.g., part of a single-piece article that may share structures and materials. In other cases, physically connected elements may comprise discrete components that may be fastened together in any fashion. Physical connections may also include a combination of discrete components fastened together, and components fashioned as a single piece.

Furthermore, as will become apparent in this specification, certain antenna components may be described as being configured for generating a resonance at a given frequency and/or resonating at a given frequency and/or having a resonance at a given frequency. In general, an antenna component that is configured to resonate at a given frequency, and the like, can also be described as having a resonant length and/or a radiation length, an electrical length and the like corresponding to the given frequency. The electrical length can be similar to or different from a physical length of the antenna component. However, the electrical length of the antenna component can also be different from the physical length, for example by using electronic components to effectively lengthen the electrical length as compared to the physical length. However, the term electrical length is most often used with respect to simple monopole and/or dipole antennas. The resonant length can be similar to, or different from, the electrical length and the physical length of the antenna component. In general, the resonant length corresponds to an effective length of an antenna component used to generate a resonance at the given frequency; for example, for irregularly shaped and/or complex antenna components that resonate at a given frequency, the resonant length can be described as a length of a simple antenna component, including but not limited to a monopole antenna and a dipole antenna, that resonates at the same given frequency.

An aspect of the specification provides a device comprising: a chassis comprising a ground plane; an antenna feed, a ground side of the antenna feed connected to the ground plane; and, an antenna comprising: a first radiating arm configured for generating a first resonance at a first frequency, the first radiating arm connected to the ground plane; a second radiating arm configured for generating a second resonance at a second frequency higher than the first frequency, the second radiating arm connected to the ground plane; and a third radiating arm configured for generating a third resonance at a third frequency higher than the second frequency, the first radiating arm capacitively coupled to the third radiating arm, and the third radiating arm connected to a positive side of the antenna feed.

The first resonance can comprise a frequency range from about 700 MHz to about 960 MHz.

The second resonance can comprise a frequency range from about 1710 MHz to about 2170 MHz.

The third resonance can comprise a frequency range from about 2500 MHz to about 2700 MHz.

The third radiating arm can comprise a first rectangle and a second rectangle smaller than the first rectangle and forming an L-shape with the first rectangle.

The first radiating arm and the second radiating arm can be arranged along a line, and radiating ends of each of the first radiating arm and the second radiating arm can be separated by a gap for preventing capacitive coupling there between. The chassis can define an opening and the first radiating arm and the second radiating arm can extend along an outer edge of the opening. The third radiating arm can be located within the opening. The first radiating arm and the third radiating arm can be capacitively coupled across a gap. The gap can be less than about 1 mm wide. The first radiating arm can comprise a larger width than a remainder of the first radiating arm in a region that forms the gap with the third radiating arm. The region can be about 23.5 mm long.

The first radiating arm can be about 53 mm long.

The second radiating arm can be about 11 mm long.

The third radiating arm can comprise a first rectangle that can be about 6.5 mm by about 25 mm, and a second rectangle extending from a small edge of the first rectangle, and the second rectangle can be about 5 mm by about 3.3 mm.

One or more of the first radiating arm and the second radiating arm can be L-shaped.

The chassis can comprise one or more of a conducting material and a conducting metal.

The antenna can be at least partially integrated with the chassis.

The first radiating arm and the second radiating arm can be connected to the chassis using attachment portions.

FIG. **1** depicts a schematic diagram of a mobile electronic device **101**, referred to interchangeably hereafter as device **101**. Device **101** comprises: a chassis **109** comprising a ground plane; and antenna feed **111**, a ground side (labelled "–" in FIG. **1**) of antenna feed **111** connected to the ground plane, and a coupled-feed wideband antenna **115**, described in further detail below. Coupled-feed wideband antenna **115** will be interchangeably referred to hereafter as antenna **115**. Device **101** can be any type of electronic device that can be used in a self-contained manner to communicate with one or more communication networks using antenna **115**. Device **101** includes, but is not limited to, any suitable combination of electronic devices, communications devices, computing devices, personal computers, laptop computers, portable electronic devices, mobile computing devices, portable computing devices, tablet computing devices, laptop computing devices, desktop phones, telephones, PDAs (personal digital assistants), cellphones, smartphones, e-readers, internet-enabled appliances and the like. Other suitable devices are within the scope of present implementations. Device hence further comprise a processor **120**, a memory **122**, a display **126**, a communication interface **124** that can optionally comprise antenna feed **111**, at least one input device **128**, a speaker **132** and a microphone **134**.

It should be emphasized that the structure of device **101** in FIG. **1** is purely an example, and contemplates a device that can be used for both wireless voice (e.g. telephony) and wireless data communications (e.g. email, web browsing, text, and the like). However, FIG. **1** contemplates a device that can be used for any suitable specialized functions, including, but not limited, to one or more of, telephony, computing, appliance, and/or entertainment related functions.

Device **101** comprises at least one input device **128** generally configured to receive input data, and can comprise any suitable combination of input devices, including but not limited to a keyboard, a keypad, a pointing device, a mouse, a track wheel, a trackball, a touchpad, a touch screen and the like. Other suitable input devices are within the scope of present implementations.

Input from input device **128** is received at processor **120** (which can be implemented as a plurality of processors, including but not limited to one or more central processors (CPUs)). Processor **120** is configured to communicate with a memory **122** comprising a non-volatile storage unit (e.g. Erasable Electronic Programmable Read Only Memory ("EEPROM"), Flash Memory) and a volatile storage unit (e.g. random access memory ("RAM")). Programming instructions that implement the functional teachings of device **101** as described herein are typically maintained, persistently, in memory **122** and used by processor **120** which makes appropriate utilization of volatile storage during the execution of such programming instructions. Those skilled in the art will now recognize that memory **122** is an example of computer readable media that can store programming instructions executable on processor **120**. Furthermore, memory **122** is also an example of a memory unit and/or memory module.

Processor **120** can be further configured to communicate with display **126**, and microphone **134** and speaker **132**. Display **126** comprises any suitable one of, or combination of, CRT (cathode ray tube) and/or flat panel displays (e.g. LCD (liquid crystal display), plasma, OLED (organic light emitting diode), capacitive or resistive touchscreens, and the like). Microphone **134**, comprises any suitable microphone for receiving sound and converting to audio data. Speaker **132** comprises any suitable speaker for converting audio data to sound to provide one or more of audible alerts, audible communications from remote communication devices, and the like. In some implementations, input device **128** and display **126** are external to device **101**, with processor **120** in communication with each of input device **128** and display **126** via a suitable connection and/or link.

Processor **120** also connects to communication interface **124** (interchangeably referred to interchangeably as interface **124**), which can be implemented as one or more radios and/or connectors and/or network adaptors, configured to wirelessly communicate with one or more communication networks (not depicted) via antenna **115**. It will be appreciated that interface **124** is configured to correspond with network architecture that is used to implement one or more communication links to the one or more communication networks, including but not limited to any suitable combination of USB (universal serial bus) cables, serial cables, wireless links, cell-phone links, cellular network links (including but not limited to 2G, 2.5G, 3G, 4G+ such as UMTS (Universal Mobile Telecommunications System), GSM (Global System for Mobile Communications), CDMA (Code division multiple access), FDD (frequency division duplexing), LTE (Long Term Evolution), TDD (time division duplexing), TDD-LTE (TDD-Long Term Evolution), TD-SCDMA (Time Division Synchronous Code Division Multiple Access) and the like, wireless data, Bluetooth links, NFC (near field communication) links, WLAN (wireless local area network) links, WiFi links, WiMax links, packet based links, the Internet, analog networks, the PSTN (public switched telephone network), access points, and the like, and/or a combination.

Specifically, interface **124** comprises radio equipment (i.e. a radio transmitter and/or radio receiver) for receiving and transmitting signals using antenna **115**. It is further appreciated that interface **124** can comprise antenna feed **111**, which alternatively can be separate from interface **124**.

It is yet further appreciated that device **101** comprises a power source, not depicted, for example a battery or the like. In some implementations the power source can comprise a connection to a mains power supply and a power adaptor (e.g. and AC-to-DC (alternating current to direct current) adaptor).

It is yet further appreciated that device **101** further comprises an outer housing which houses components of device **101**, including chassis **109**. Chassis **109** can be internal to the outer housing and be configured to provide structural integrity to device **101**. Chassis **109** can be further configured to support components of device **101** attached thereto, for example, display **126**. In specific implementations chassis **109** can comprise one or more of a conducting material and a conducting metal, such that chassis **109** forms the ground plane; in alternative implementations, at least a portion of chassis **109** can comprise one or more of a conductive covering and a conductive coating which forms the ground plane.

In any event, it should be understood that a wide variety of configurations for device **101** are contemplated.

Attention is next directed to FIG. **2**, which depicts non-limiting implementations of antenna **115** at least partially integrated with chassis **109**. Specifically, FIG. **2** depicts an internal portion of device **101** that includes chassis **109** comprising ground plane **200**, connection portions of antenna feed **111**, and antenna **115**. It is appreciated that FIG. **2** does not depict all of chassis **109**, but a portion that includes antenna **115**.

In general, antenna **115** comprises: a first radiating arm **201** configured for generating a first resonance at a first frequency, first radiating arm **201** connected to ground plane **200** (i.e. as depicted, first radiating arm **201** is connected to chassis **109**); a second radiating arm **202** configured for generating a second resonance at a second frequency higher than the first frequency, second radiating arm **202** connected to ground plane **200** (i.e. as depicted, second radiating arm **202** is connected to chassis **109**); and a third radiating arm **203** configured for generating a third resonance at a third frequency higher than the second frequency, first radiating arm **201** capacitively coupled to third radiating arm **203**, and third radiating arm **203** connected to a positive side of antenna feed **111** (i.e. a side opposite the ground side of antenna feed **111**, and/or the side labelled "+" in FIG. **1**).

In these implementations first radiating arm **201** and second radiating arm **202** are integrated with chassis **109** and hence ground plane **200**; hence components of antenna **115** are indicated In FIG. **2** using stippled lines. Hence, each of first radiating arm **201** and second radiating arm **202** comprise monopole parasitic components in communication with antenna feed **111** using third radiating arm **203**.

Furthermore, third radiating arm **203** comprises a monopole antenna located in an opening **205** formed by first radiating arm **201**, second radiating arm **202** and chassis **109**. Specifically, first radiating arm **201** and second radiating arm **202** are arranged along a line along an outer side of chassis **109**, and radiating ends of each of first radiating arm **201** and second radiating arm **202** are separated by a gap **207** for preventing capacitive coupling there between. In other words, gap **207** is wide enough so that capacitive coupling does not occur between first radiating arm **201** and second radiating arm **202**. Furthermore, in depicted implementations, as first radiating arm **201** and second radiating arm **202** are integrated with chassis **109**, chassis **109** defining and/or forming opening **205**, and first radiating arm **201** and second radiating arm **202** extend along an outer edge of opening **205**. Further gap **207** extends from an outer edge of each of first radiating arm **201** and second radiating arm **202** into opening **205**.

Third radiating arm is located within opening **205** but is not electrically connected to chassis **109** other than through antenna feed **111**. In depicted implementations, third radiating arm **203** comprises a first rectangle **209** and a second rectangle **211** smaller than first rectangle **209** and forming an L-shape with first rectangle **209**; further, as depicted first radiating arm **201** is capacitively coupled to third radiating arm **203** along a portion of first rectangle **209** but not second rectangle **211**. However, in other implementations, first radiating arm **201** can be capacitively coupled to third radiating arm **203** along a portion of one or more of first rectangle **209** and second rectangle **211**.

It is yet further appreciated that first radiating arm **201** and third radiating arm **203** are capacitively coupled across a gap **213** there between. In other words, gap **213** is small enough for capacitive coupling to occur between first radiating arm **201** and third radiating arm **203**; this effects the resonance frequency of each and allows for greater versatility in designing antenna **115**. Indeed, antenna feed **111** can hence feed first radiating arm **201** using both ground plane **200** and the capactive coupling with third radiating arm **203** across gap **213**.

A width of gap **213** can be controlled by widening at least a portion of first radiating arm **201**. For example, in depicted implementations, first radiating arm **201** comprises a larger width than a remainder of first radiating arm **201** in a region **215** that forms gap **213** with third radiating arm **203**. Widening of first radiating arm **201** is described below with reference to FIG. **8**.

It is further appreciated that antenna **115** is configured to generate resonances at three frequencies corresponding to each of first radiating arm **201**, second radiating arm **202** and third radiating arm **203**. In specific non-limiting implementations, antenna **115** can be configured to generate resonances in frequency bands corresponding to one or more of LTE frequency bands, GSM frequency bands, UMTS frequency bands and WLAN frequency bands.

For example, attention is directed to FIG. **3** which depicts a return-loss curve for specific non-limiting implementations of successful prototypes of antenna **115** between about 650 MHz and about 3000 MHz (or 3 GHz), with return-loss shown on the Y-axis and frequency shown on the x-axis.

In these implementations, first radiating arm **201** generates the first resonance at a first frequency, the first resonance comprising a frequency range of about 700 MHz to about 960 MHz (e.g. including point 1 at about 734 MHz, point 2 at about 821 MHz, and point 4 at about 960 MHz on the return-loss curve). In other words, from FIG. **3** it is apparent that the first frequency is about 800 MHz, and the first resonance has a bandwidth that includes frequencies in a frequency range of about 700 MHz to about 960 MHz.

However, by adjusting the dimensions of antenna **115**, both the first frequency and the bandwidth of the first resonance can be tuned.

Further, second radiating arm **202** generates the second resonance, the second resonance comprising a frequency range of about 1710 MHz to about 2170 MHz (e.g. including point 3 at about 1710 MHz, point 5 at about 1805 MHz, point 6 at about 1930 MHz and point 7 at about 2170 MHz on the return-loss curve). In other words, from FIG. **3** it is apparent that the second frequency is about 1930 MHz, and the first resonance has a bandwidth that includes frequencies in a frequency range of about 1710 MHz to about 2170 MHz. However, by adjusting the dimensions of antenna **115**, both the second frequency and the bandwidth of the second resonance can be tuned.

Further, third radiating arm **203** generates the third resonance, the third resonance comprising a frequency range of about 2500 MHz to about 2700 MHz (e.g. including point 8 at about 2500 MHz and point 9 at about 2690 MHz on the return-loss curve). In other words, from FIG. **3** it is apparent that the third frequency is about 2670 MHz, and the first resonance has a bandwidth that includes frequencies in a frequency range of about 2500 MHz to about 2700 MHz. However, by adjusting the dimensions of antenna **115**, both the third frequency and the bandwidth of the third resonance can be tuned.

Furthermore, antenna **115** can achieve good efficiency over these frequency ranges. For example, attention is directed to FIG. **4** which depicts efficiency of specific non-limiting implementations the successful prototypes of antenna **115** over a similar frequency range as that depicted in FIG. **3**, with efficiency shown on the y-axis and frequency shown on the x-axis. The poorest efficiency is about −4.5 dB, around 950 MHz, while the best efficiency is around −0.8 dB at around 2060 MHz, with a relatively flat efficiency from about 1710 MHz to about 2700 MHz.

Dimensions and/or shapes of antenna **115** and each of first radiating arm **201**, second radiating arm **202** and third radiating arm **203** can be varied heuristically and/or experimentally to determine dimensions for achieving the return-loss curve of FIG. **3** and the efficiency of FIG. **4**. For example, attention is directed to FIG. **5** which depicts a subset of the portion of chassis **109** depicted in FIG. **2**, and first radiating arm **201**, second radiating arm **202** and third radiating arm **203**, as well as dimensions thereof used to achieve the return-loss curve of FIG. **3** and the efficiency of FIG. **4** in a successful prototype.

In these implementations, first radiating arm **201** is about 53 mm long, second radiating arm **202** is about 11 mm long, and third radiating arm **203** comprises first rectangle **209** that is about 6.5 mm by about 25 mm, and second rectangle **211** extending from a small edge of first rectangle **209**, second rectangle **211** being about 5 mm by about 3.3 mm.

First radiating arm **201** is capacitively coupled to third radiating arm **203** across gap **213**, gap **213** being less than about 1 mm. Furthermore, region **215** is about 23.5 mm long, slightly less than the length of about 25 mm of first rectangle **209**.

Gap **207** between first radiating arm **201** and second radiating arm **202** is about 3 mm. Each of first radiating arm **201** and second radiating arm **202** is about 4.5 mm wide, and region **215** is about 2.5 mm wider than a remainder of first radiating arm **201**.

Opening **205** is about 67 mm by about 10 mm, and furthermore, as depicted, a right edge of third radiating arm **203** is located about 29.5 mm from a right edge of opening **205**. A left edge of first rectangle **209** of third radiating arm **203** is located about 12.5 mm from a left edge of opening **205**. Further, a bottom edge of third radiating arm **203** is separated from chassis **109** by a gap of less than about 1 mm; in some implementations the gap between a bottom edge of third radiating arm **203** and chassis is about 0.7 mm. It is appreciated, however, that the terms "right", "left", and "bottom" are only meant to refer to FIG. **5** and is not meant to imply that the referred to edges are always located on the right or on the bottom; rather, components depicted in FIG. **5** can be rotated in any given direction.

However, while specific dimensions are depicted in FIG. **5**, in other implementations, other dimensions and/or shapes of components of antenna **115** can be used to achieve resonances at different bandwidths.

It is further appreciated that, in present implementations, a chassis of a device can be adapted to form at least a portion of antenna **115**. For example, attention is directed to FIG. **6**, which depicts a same portion of chassis **109** of device **101** as in FIG. **2**, prior to chassis **109** being adapted to form antenna **115**. It is appreciated that chassis **109** forms opening **205** and chassis **109** further includes ground plane **200**. Opening **205** can be a feature of chassis **109** provided specifically for an antenna structure, such as antenna **115**. In any event, stippled vertical lines **601** correspond to edges of gap **207** and it is appreciated that the area of chassis **109** between lines **601** can be removed and/or machined away to form first radiating arm **201**, second radiating arm **202** and gap **207**.

Indeed, attention is next directed to FIG. **7** which is similar to FIG. **6**, however material from the area of chassis **109** between lines **601** has been removed and/or machined away to form first radiating arm **201**, second radiating arm **201**, and gap **207**.

In some implementations, a width of first radiating arm **201** can initially be about a width of region **215** and material can be removed, machined away and the like to narrow a width of first radiating arm **201** except in region **215**. Indeed, the method of forming region **215** is generally appreciated to be non-limiting.

In alternative implementations, and as depicted in FIG. **8**, first radiating arm **201** can be adapted to increase a width of first radiating arm **201** in region **215**. FIG. **8** is similar to FIG. **6**, but with conducting material added to region **215** to widen first radiating arm **201**. For example, as depicted, one or more of conducting foil, conducting material and the like can be wrapped around and/or attached to first radiating arm **201** in region **215** to widen first radiating arm, presuming electrical contact is made between the conducting foil, conducting material and the like and first radiating arm **201**; alternatively, conducting material can be attached to an edge of first radiating arm **201** in region **215** to widen first radiating arm **201**.

It is further appreciated that, in some implementations, region **215** can be integral with a remainder of first radiating arm **201** (e.g. as in FIG. **2**), while in other implementations region **215** can be removably attached to a remainder of first radiating arm **201**, as in FIG. **8**.

It is appreciated that chassis **109** depicted in FIG. **8** can then be further adapted to add third radiating arm **203** as depicted in FIG. **2**. For example, third radiating arm **203** can be mounted on non-conducting material within opening **205** and/or underneath opening **205**.

Hence, the sequence of FIGS. **6**, **7**, **8** and **2** depict chassis **109** being adapted to include antenna **115**. However, the steps for adapting chassis **109** to include antenna **115** need not be performed in the order as described above. For example, gap **207** can be formed before or after region **215** is formed and/or third radiating arm **203** is added. Indeed the sequence depicted in FIGS. **6**, **7**, **8** and **2** can be performed in any order that results in the configuration of FIG. **2**.

Attention is next directed to FIG. **9**, which depicts an alternate chassis **109***a* comprising a ground plane **200***a* and an opening **205***a*, respectively similar to chassis **109** and ground plane **200**, however opening **205***a* comprises an open cutout of chassis **109***a* rather than an aperture. In any event, attention is next directed to FIG. **10** which depicts chassis **109***a* adapted to include an antenna **115***a*, which is similar to antenna **115**. FIG. **10** is similar to FIG. **2**, with like elements having like numbers, but with an "a" appended thereto; further, while not all components of FIG. **10** are labelled similar to FIG. **2**, they are appreciated to be nonetheless present.

Hence, antenna **115***a* comprises a first radiating arm **201***a* having a region **215***a*, a second radiating arm **202***a*, and a third radiating arm **203***a*, each respectively similar to first radiating arm **201**, second radiating arm **202**, and third radiating arm **203**, with a gap **207***a* between first radiating arm **201***a* and second radiating arm **202***a*, similar to gap **207**, and a gap **213***a* between first radiating arm **201***a*, and third radiating arm **203***a*, similar to gap **213**. Further, an antenna feed **111***a* is connected to third radiating arm **203***a* and ground plane **200***a*, similar to antenna feed **111**. In other words, antenna **115***a* is similar to antenna **115**, however first radiating arm **201***a* and second radiating arm **202***a* are not integral with chassis **109***a*; rather first radiating arm **201***a* and second radiating arm **202***a* are physically and electrically attached to chassis **109***a* using respective attachment portions **1001**. Each attachment portion **1001** can comprise one or more of a spring, an electrical connector, a conducting material and the like; however, in general, respective attachment portions **1001** are each configured to attach first radiating arm **201***a* and second radiating arm **202***a* to chassis **109***a* in opening **205***a*.

Persons skilled in the art will appreciate that there are yet more alternative implementations and modifications possible. For example, attention is directed to FIG. **11** which depicts another non-limiting implementation of a chassis **109***b* comprising a ground plane **200***b*, an opening **205***b*, and an antenna **115***b*, similar to antenna **115**. Indeed, FIG. **11** is similar to FIG. **2**, with like elements having like numbers, but with a "b" appended thereto; further, while not all components of FIG. **11** are labelled similar to FIG. **2**, there are appreciated to be nonetheless present. Hence, antenna **115***b* comprises a first radiating arm **201***b*, having a region **215***b*, a second radiating arm **202***b*, and a third radiating arm **203***b*, each respectively similar to first radiating arm **201**, second radiating arm **202**, and third radiating arm **203**, with a gap **207***b* between first radiating arm **201***b* and second radiating arm **202***b*, similar to gap **207**, and a gap **213***b* between first radiating arm **201***b*, and third radiating arm **203***b*, similar to gap **213**. Further, an antenna feed **111***b* is connected to third radiating arm **203***b* and ground plane **200***b*, similar to antenna feed **111**. Hence, antenna **115***b* is similar to antenna **115**, however each of first radiating arm **201***b* and second radiating arm **202***b* are "L" shaped, at respective radiating ends adjacent gap **207***b*. Indeed, in other implementations, only one of first radiating arm **201***b* and second radiating arm **202***b* can be "L" shaped. Further the specific shape of each of first radiating arm **201***b*, second radiating arm **202***b* and third radiating arm **203***b* are not specifically limited to those shapes depicted herein, but can be determined heuristically and/or experimentally.

In any event, a versatile coupled-feed wideband antenna is described herein that can replace a plurality of antennas at a mobile electronic device. The specific resonance bands of the antennas described herein can be varied by varying the dimensions of components of the antenna to advantageously align the bands with bands used by service providers to provide communication providers. Further, the present antenna obviates the need to use different antennas for different bands in different regions as the width of resonance in each frequency band is also wide enough to accommodate a plurality of channels in each band.

Persons skilled in the art will appreciate that there are yet more alternative implementations and modifications possible, and that the above examples are only illustrations of one or more implementations. The scope, therefore, is only to be limited by the claims appended here.

What is claimed is:

1. A device comprising:

a chassis comprising a ground plane;

an antenna feed, a ground side of the antenna feed connected to the ground plane; and,

an antenna comprising:

a first radiating arm configured to generate a first resonance at a first frequency, the first radiating arm connected to the ground plane;

a second radiating arm configured to generate a second resonance at a second frequency higher than the first frequency, the second radiating arm connected to the ground plane; the first radiating arm, the second radiating arm and the ground plane defining edges of an opening, the first radiating arm and the second radiating arm extending towards each other from the ground plane and arranged along a line extending along an outer edge of the opening; radiating ends of each of the first radiating arm and the second radiating arm separated by a first gap along the line; and

a third radiating arm configured to generate a third resonance at a third frequency higher than the second frequency, the third radiating arm connected to a positive side of the antenna feed, the third radiating arm located within the opening, and separated from the ground plane by at least a second gap configured to electrically isolate the third radiating arm from the ground plane, the first radiating arm and the third radiating arm being capacitively coupled across a third gap and otherwise being isolated from each other such that there is no direct connection between the positive side of the antenna feed and either of the first radiating arm and the second radiating arm, each of the ground plane, the first radiating arm, the second radiating arm, the opening and the third radiating arm all being in a common plane.

2. The device of claim **1**, wherein the first resonance comprises a frequency range from about 700 MHz to about 960 MHz.

3. The device of claim **1**, wherein the second resonance comprises a frequency range from about 1710 MHz to about 2170 MHz.

4. The device of claim **1**, wherein the third resonance comprises a frequency range from about 2500 MHz to about 2700 MHz.

5. The device of claim **1**, wherein the third radiating arm comprises a first rectangle and a second rectangle smaller than the first rectangle and forming an L-shape with the first rectangle.

6. The device of claim **1**, wherein the first gap between the first radiating arm and the second radiating arm is configured to prevent capacitive coupling there between.

7. The device of claim **1**, wherein the third gap is less than about 1 mm wide.

8. The device of claim **1**, wherein the first radiating arm comprises a larger width than a remainder of the first radiating arm in a region that forms the third gap with the third radiating arm.

9. The device of claim **8**, wherein the region is about 23.5 mm long.

10. The device of claim **1**, wherein the first radiating arm is about 53 mm long.

11. The device of claim **1**, wherein the second radiating arm is about 11 mm long.

12. The device of claim **1**, wherein the third radiating arm comprises a first rectangle that is about 6.5 mm by about 25 mm, and a second rectangle extending from a small edge of the first rectangle, the second rectangle being about 5 mm by about 3.3 mm.

13. The device of claim **1**, wherein one or more of the first radiating arm and the second radiating arm are L-shaped.

14. The device of claim **1**, wherein the ground plane comprises one or more of a conducting material and a conducting metal.

15. The device of claim **1**, wherein the antenna is at least partially integrated with the chassis.

16. The device of claim **1**, wherein the first radiating arm and the second radiating arm are connected to the ground plane using attachment portions.

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